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Three Dimensional Mapping Of Shipping Containers Depot Using Unmmaned Aerial Vehicle (UAV)

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Abstract

Managing and planning depot area consisting of shipping containers are of high interest in transport and logistics. The role of Unmanned Aerial Vehicle (UAV) in fast mapping for a shipping containers depot is demonstrated. The technique comprises of UAV fitted with high resolution digital camera to capture aerial images covering the depot area. The aerial images are captured in series with calculated overlaps for the construction of 3D models and orthophoto by utilizing the photogrammetric techniques. Orthophoto is an aerial photograph or image geometrically corrected such that the scale is uniform and depicts a map. Information such as the 3D models and orthophoto will be of high value towards managing and planning of depot area. Apart from the 3D model and orthophoto constructed, an automated counting of the shipping containers for the depot area based on the 3D models constructed will also be demonstrated. Constructed 3D models, orthophoto and the automatic approached in counting shipping containers for a selected study depot area will be shown and discussed.

Keywords: Shipping container depot development, UAV, ArcGIS, Photogrammetry, 3D mapping

Introduction

In Malaysia, based on the report by Port Klang Authority's Official Portal (2018), there are increasing growths of container in Port Klang since year 2005 until 2017 (Figure 1). Port Klang is experiencing growth of 11% Twenty-foot Equivalent Units (TEUs) to be handled in year 2016 with total 13.17 million TEUs compared to only 11.89 million TEUs in the previous year (Starbiz, 2017). Systematic improvement in management is of high priority, as it will be difficult for the container terminal authority to cope with huge amounts of TEUs in the future and the factor of operational efficiency will be questionable.

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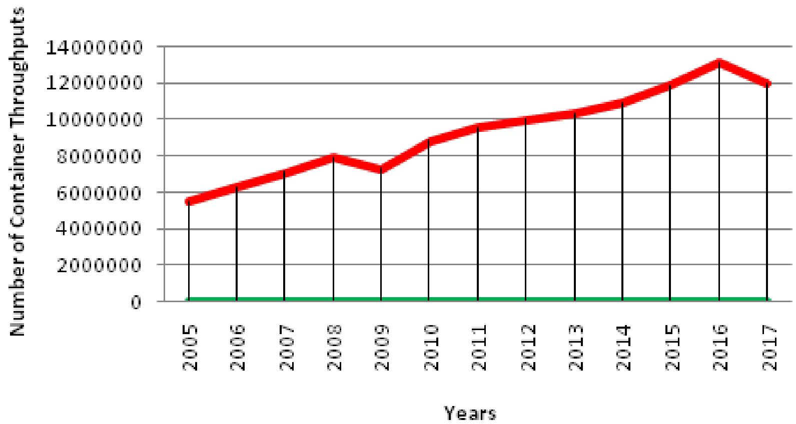

Figure 1. Total Number of Container in Port Klang from Year 2005 to 2017 (Port Klang Authority, 2018)

The issue of space limitations at the depot to store the containers will arise due to the rapid growth of the containers to be handled. Various research has been carried out on new approached in container stacking or storage system due to limitation in space at the container yard In one study, it is found that three main factors that causing the lack of space at the container yard are due to the limitations of the container yard area, high volume of containers to be handled and high volume of vessels that entering the port at one time (Rahman et al., 2016).

Chuanyu et al., (2015) stated that under his study on optimization of container yard operations, among hierarchical structure of decision-makings in container terminals, the yard planning is considered to be the most important part that will affect the efficiency of port management. A storage yard that is well-designed and planned will improve port performance by optimizing the space utilization.

Furthermore, Jeevan et al., (2015) found that the Prai Bulk Cargo Terminal (PBCT) and Ipoh Container Terminal (ICT), Malaysia are the two inland dry ports or depots that are highly experiencing the insufficient space to accommodate a high volume of containers. Due to this, the arrangements of shipping containers at the terminal need to be optimized in order to maximize the number of containers that can be stored in the depot area. The need of a detail layout plan to assist the task is important. Conventional surveying (Saikia et al., 2010) approach could be

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carried out to prepare the existing layout plan. However, the limitation of information gathered using conventional surveying technique will be low value in planning a depot area. It should be pointed out; that the high activities at depot area will also hinder the progress of conventional surveying technique.

In recent development, UAV application is suitable for low-budget and large scale mapping for small area with short operational time (Anuar et al, 2013). A study has been conducted to determine the effectiveness of UAV aerial images system to be applied for large scale mapping and found that it provides a new technical means for rapid mapping with various advantages (Gao et al., 2017).

A UAV mapping product includes 3D models and orthophoto which are a valuable source for data inspection, surveillance, mapping and for 3D modeling of the milieu (Nex & Romandino, 2014).

The main purpose of this study is to investigate the accuracy of the information gathered using UAV which includes 3D models and orthophoto to assist depot planning purposes. A new approach towards automated counting of shipping containers based on the digital models retrieved will also be documented and discussed.

Method

The proposed approach comprises of three phases which starts with data collection, digital image post-processing and finally the geographical information processing stage as shown in Figure 2.

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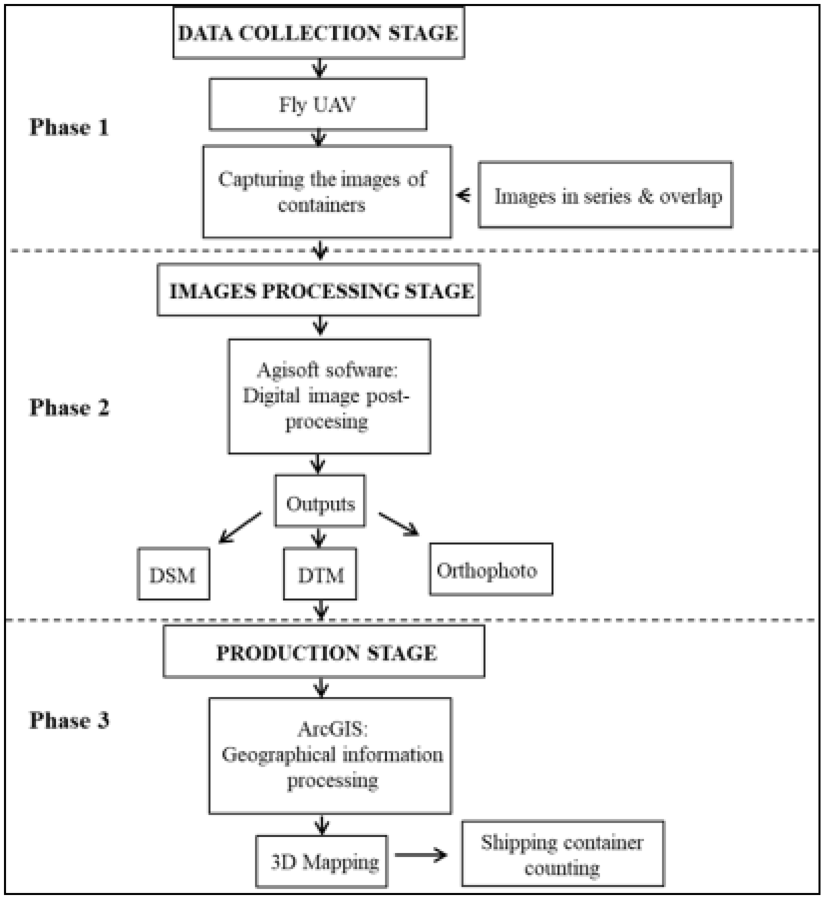

Figure 2. Steps in UAV image processing

The data collection phase involves deployment of the UAV that fitted with digital camera to capture the aerial images covering the depot. Figure 3 shows the UAV model deployed for the data acquisition phase.

Figure 3. UAV DJI Phantom 4 Pro fitted with Digital Camera (DJI, 2018)

Referring to Figure 3, the simplified specification for the UAV used in the study is as shown in Table 1.

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Table 1. Summary of Significance Test and Linearity Test Results (DJI, 2018)

Components	Specifications
Product Position	Entry-level professional drone with powerful obstacle avoidance
Weight (Battery & Propellers included)	1388g
Max Flight Time	Approximately 30 minutes
Vision System	Forward
	Backward
	Downward
Obstacle Sensing	Front & rear obstacle avoidance
	Left & right infrared obstacle avoidance
Camera Sensor (1st DJI Mechanical Shutter)	1-inch CMOS
	Effective pixels: 20 M
Max Video Recording Resolution (100Mbps bitrate)	4K 60fps (H.264)
	4K 30fps (H.265)
Max Transmission Distance	FCC: 4.3 miles (~7km)
Focal Length	24mm

The images are captured in series and overlap to meet the principle of photogrammetric technique (Saikia et al, 2010, Venkatramaiah, 2011 & Natural Resource Canada, 2016). The overlap is required in order to construct the 3D models (Duggal, 2004, Khairul et al., 2011 & Remondino et al., 2012).

The next phase is the digital image post-processing phase where the collected images were imported into the digital image post-processing software, Agisoft Photoscan (Agisoft, 2018a) that utilized the photogrammetric technique (Saikia et al, 2010;Venkatramaiah, 2011 & Natural Resource Canada, 2016) for the production of mapping and 3D modeling (Khairul et al., 2011; Remondino et al., 2012 & Agisoft, 2018b) is used. The software is one of the standard software used in image processing. The output of the process includes i) Digital Surface Model (DSM) that portrays the height of the ground surface which include the above surface features such as building and tress (Gomarasca, 2009 & Remondino et al., 2012). ii) Digital Terrain Model that model the ground surface only

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(Gomarasca, 2009) and iii) Orthophoto of the area where it resembles an image map that is true in orientation and scale (Barazzetti et al., 2014). Batch Processing tool available in Agisoft is executed to produce the outputs mentioned (Agisoft, 2018b).

Result and Analysis

Figure 4 shows the constructed a) Digital Surface Model (DSM) and b) Digital Terrain Model (DTM) for the study area. Referring to Figure 6, the main advantage of the constructed model includes; the height of the containers and the surroundings could be retrieved from the models with the aid of the software in used namely ArcGIS (Esri, 2018a). Information retrieved such as the heights and distances between each points of interest will be great value towards planning and other development purposes. The accuracy of the model is tested with at least 30 randomly known points on the ground. The RMSE (Root Mean Square Error) is 0.5 meter for both the DSM and DTM, it should be pointed out that with this accuracy, detecting containers with heights more than 2 meters is still possible. An ongoing research on the accuracy achieved in constructing digital models at depot area will be part of future research. Hence, with this accuracy achieved, the information retrieved from the model seems to be adequate for various planning purposes. The value showed on the legend is the minimum and maximum height value. It should be pointed out that these values might subject to isolate errors in constructing of the model using the software.

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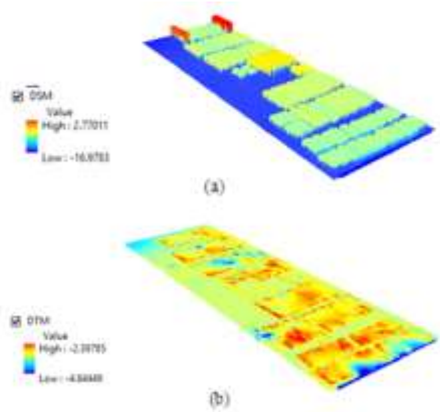

Figure 4. Constructed 3D model a) Digital Surface Model and b) Digital Terrain Model

Figure 5 shows the constructed orthophoto for the study area. The main advantage of the orthophoto is that it depicts the area as a 2D plan. The scale and orientation of the orthophoto will be of great advantage in construction such as planning for extension or arrangement of the containers. The accuracy of the orthophoto is based on 30 randomly ground points is 0.01 meter. Hence, with this accuracy, physical planning for the area could be carried out with high accuracy.

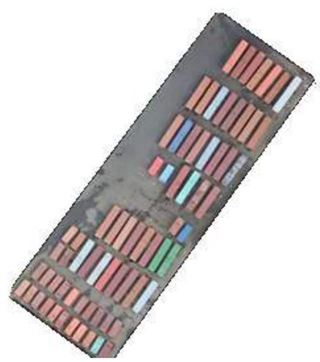

Figure 5. Orthophoto of Shipping Containers at Depot

Utilizing ArcGIS, a geo-processing GIS (Geographic Information System) software, the DTM is subtracted from the DSM, this produces a new model known as the normalized DSM (nDSM) (Figure 6). The nDSM represents the elevation or height of features above the ground elevation. In this study the nDSM for the depot area will potray the elevation of the shipping containers.

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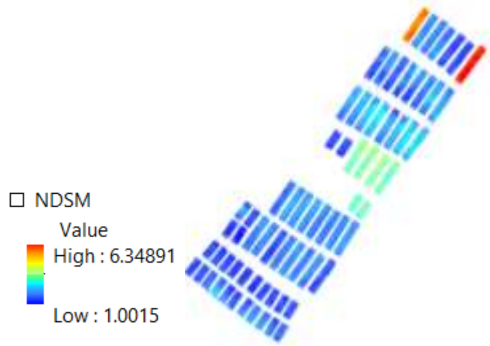

Figure 6. nDSM of Shipping Containers

Knowing the standard height of containers (ISO height of containers), the height of the nDSM is classified to determine the number containers in each stack. The number is calculated by using simple mathematical equation (1):

$$\frac{Total\ height\ of\ container}{ISO\ height\ of\ 1\ container} = number\ of\ container \qquad (1)$$

The result obtained is used to generate a thematic map showing the numbers of shipping containers at the depot (Figure 7).

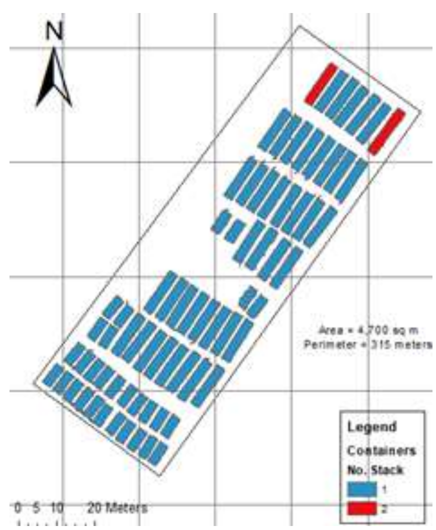

Figure 7. Number of Shipping Containers

In this study, a database is created based on the automatic counting of the containers using ArcGIS. This is done by using ModelBuilder tool in ArcGIS that

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allows user to customize the steps of operations to be executed automatically (Esri, 2018b & Burdeos et al., 2015). The results of the research concluded that the automated approach proposed is much convenience compared to manual counting. The accuracy achieved is 100% when accurate compared to the known value of containers at the study area. Further study to justify the findings and enhancing the technique will be part of the research agenda. Further analysis could then be performed as shown in Figure 8 and Figure 9 where the location of the 20ft and 40ft containers could be identified automatically since the database is built.

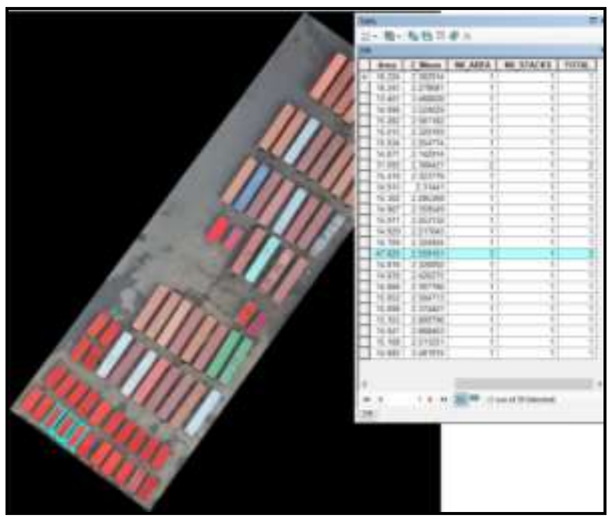

Figure 8. Number of 20-foot Container Computations

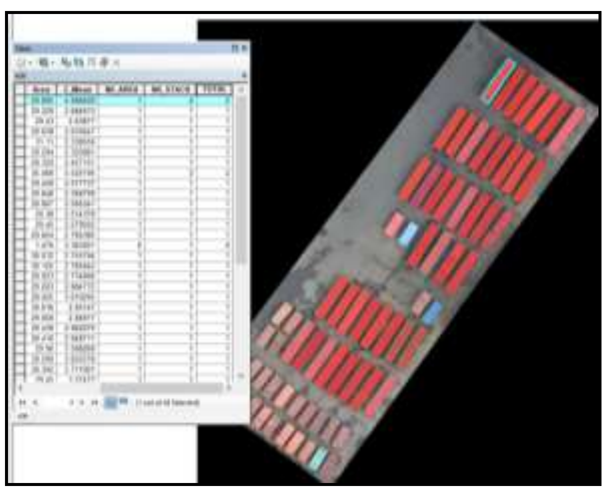

Figure 9. Number of 40-foot Container Computations

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Conclusion

The role of UAV mapping in depot planning and management is shown. The accuracy and usage of the UAV mapping products which include DSM, DTM and Orthophoto for depot physical planning is highlighted. The automated approached in counting shipping containers at dry depot based on nDSM constructed is discussed.

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